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Meas. Sci. Technol. 3 1992 (UK) S.F.Johnston "Gas monitors---infrared LEDs" pp 191-195 esp Figs 2,4

(58) Field of Search
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INT CL[6] G01N 21/31 21/33 21/35 21/39

(54) **Gas detection**

(57) A gas detection system for determining concentration of a target gas within a gas sample comprises a narrow-band light source 1, preferably a LED, arranged to illuminate the gas sample area 3, and a detection arrangement downstream of the gas sample area. The detection arrangement comprises either one or two optical detectors and, respectively, zero, or at most one, optical filter. In a preferred embodiment, as shown, a beam splitter 4 receives reflected radiation from a focusing mirror 2 and directs light along two alternative paths, the first of which leads directly to a first detector 5 and the second of which leads indirectly, via an optical filter 7, to a second detector 6. The filter 7 may pass the wavelengths corresponding to the absorption spectrum of the target gas, in which case the detector 6 is the sample detector, or may be a blocking filter in which case the detector 6 is the reference detector. The two detected signals are processed to provide a measure of the target gas concentration. By use of the narrow-band light source 1, it is possible to construct a gas detector of the present invention with one optical filter less than would be needed in the corresponding configuration known hitherto.

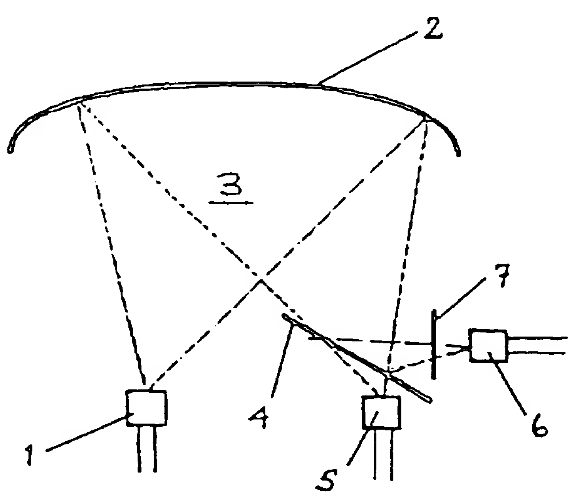

FIGURE 1

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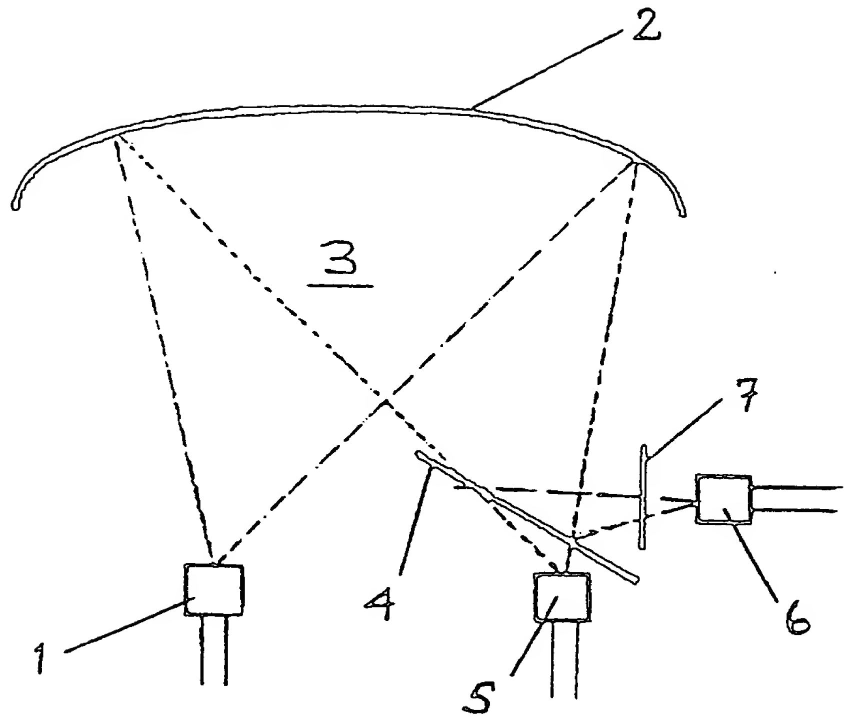

FIGURE 1

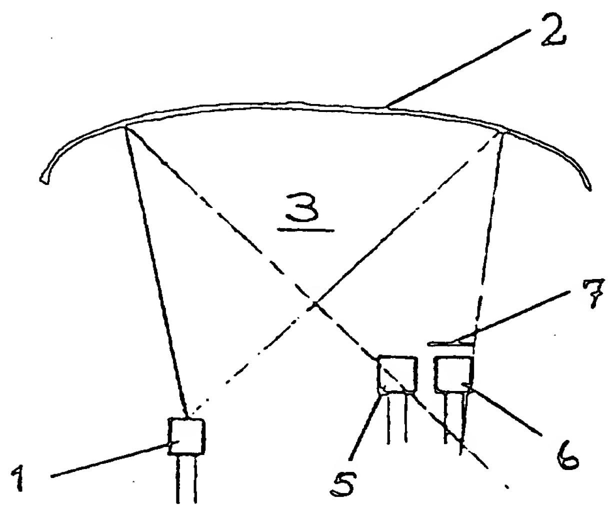

FIGURE 2

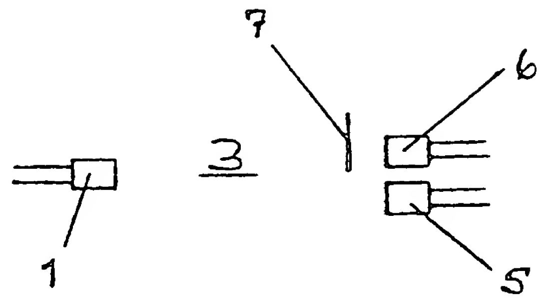

FIGURE 3

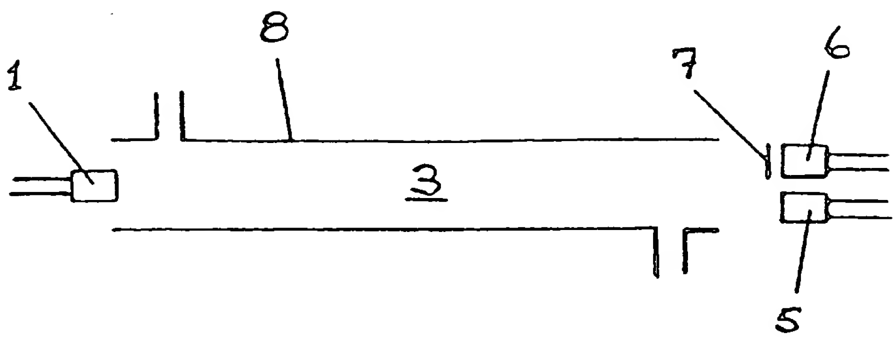

FIGURE 4

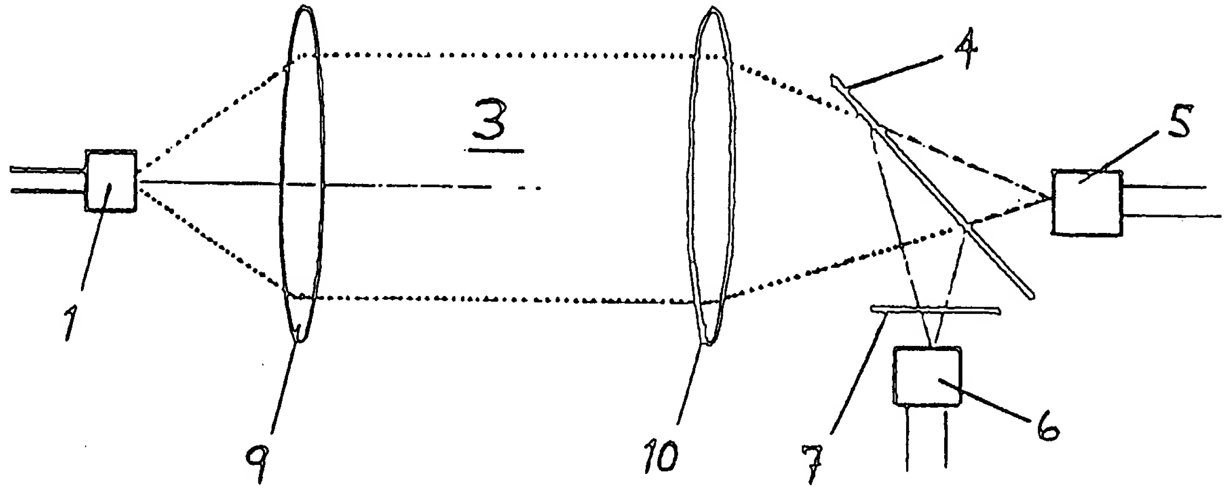

FIGURE 5

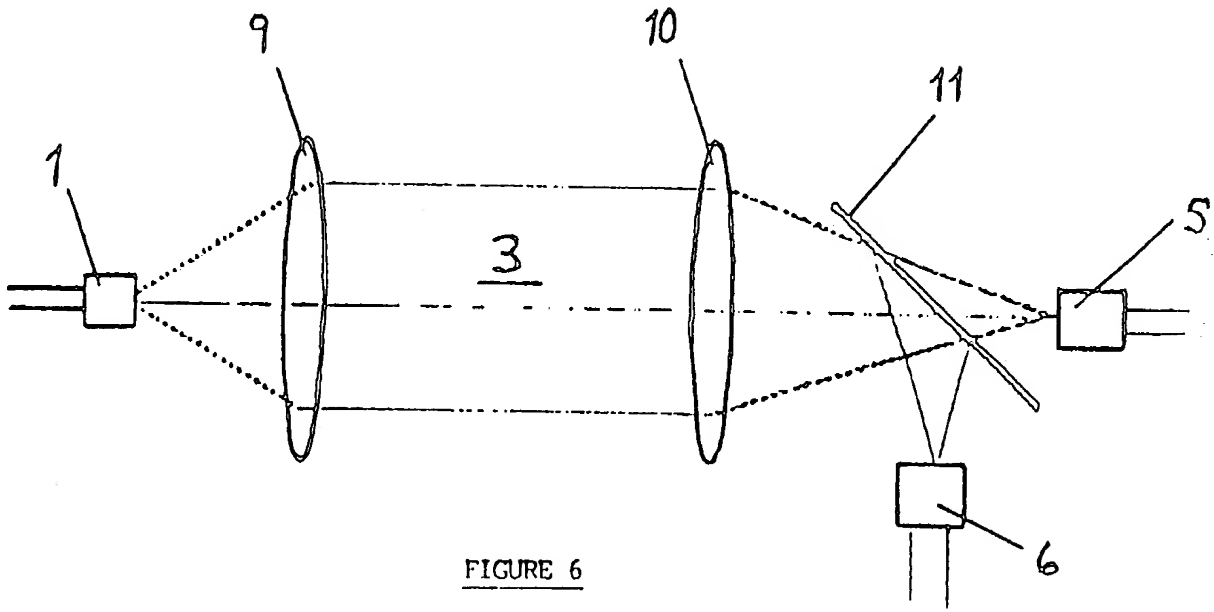

FIGURE 6

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GAS DETECTION

DESCRIPTION

The present invention relates to gas detection and is particularly concerned with a gas detection system and a gas detector which are considerably simpler and more economic to manufacture, and perform more reliably than known gas detection systems and gas detectors.

It is well known that gases exhibit characteristic optical absorption spectra which are based on their molecular structure. In a conventional approach to gas detection, gas concentration can be measured by monitoring the change of intensity of light transmitted through a gas sample, the wavelength range of the light source employed being selected to coincide with the spectral absorption region of the gas sample under investigation. The light used in this conventional approach to gas detection is normally derived from a thermal light source, such as a filament bulb, which emits light over a wide range of wavelengths.

A disadvantage of this conventional approach is that by simply measuring the change in transmitted light intensity with variations of gas sample concentration, a result is obtained which is almost totally non-gas specific, and for most practical purposes it would not be known whether the change in light intensity arose from the desired target gas or an interfering/contaminant gas within the sample under investigation.

Prior art gas detection systems have addressed

the foregoing disadvantage in two ways, namely:

1. An optical filter is placed between the light source and a single light detector to limit the range of wavelengths being received at the detector. This is a "single beam" technique.

2. The light beam, having passed through the gas sample under investigation, is passed to two detectors. In one configuration, the light path to one of these detectors includes an optical filter which transmits only in the spectral absorption region of the target gas, whilst the light path to the other of these detectors includes an optical filter which transmits light over only a limited range of wavelengths away from the spectral absorption region of the target gas. In a second configuration, a broad band optical filter is placed in the light path from the light source to the gas sample and of the light paths to the two detectors only one includes a narrow band optical filter. These alternative configurations are the "two beam" or "reference beam" techniques. In either of these alternative configurations, one of the light paths affords a reference beam which is used to correct for absorptions arising from interfering/contaminant gases within the sample, or beam obscuration; whilst the other light path affords a detection beam for measuring the concentration of the target gas within the gas sample under investigation. Whichever of these two alternative configurations is used, two optical filters are necessary.

Objects of the present invention are to provide

a gas detection system and gas detector which are simpler, more economic to manufacture and use, and more reliable than those provided by the prior art, and which eliminate, or at least reduce, disadvantages of the prior art as described above.

The broad concept of the present invention resides in the employment of a narrow-band optical source in gas detection or measurement.

According to a first aspect of the present invention, a gas detection system comprises a narrow-band optical source arranged to illuminate a gas sample area, and a detection arrangement downstream of the gas sample area.

Preferably the narrow-band optical source will be an LED (light emitting diode) source which itself limits the range of emission wavelengths because of the manner in which the fundamental LED emission process operates.

Alternatively, the narrow-band optical source may be a laser source.

The narrow-band, for example LED, optical source may be operated with either one or two detector(s).

When only one detector is used, the "single beam" configuration of a gas detection system according to the first aspect of the present invention does not include any optical filter.

Preferably, therefore, the gas detection system according to the first aspect of the present invention has the narrow-band optical source arranged to emit

optical radiation towards a single detector and along a light path including the gas sample area lying between the source and detector, and wherein no optical filter, beam splitter, or other optical element is included between the source and detector.

When two detectors are used, the "two beam" configuration of a gas detection system according to the first aspect of the present invention includes only one optical filter. The optical filter is included in the light path to only one of the two detectors.

There are several possible embodiments in a "two beam" configuration of gas detection system according to the first aspect of the present invention.

Thus, in one embodiment of the "two beam" configuration, the narrow-band optical source is arranged to emit optical radiation directly towards the two detectors and along light paths including the gas sample area lying between the source and detectors, and a single optical filter lies between the gas sample area and said one of the two detectors; in this case, no beam splitter or other optical element is included between the source and detectors.

In this embodiment, the gas sample area may be contained within a reflective tube or light concentrator which extends at least partially between the optical source and the detectors.

In another embodiment of the "two beam" configuration, the narrow-band optical source is arranged to emit optical radiation towards the two detectors and along light paths including the gas

sample area lying between the source and detectors, and a single optical filter lies between the gas sample area and said one of the two detectors; in this case an optical beam-splitter lies between the gas sample area and the two detectors.

Preferably, the gas sample area lies between the narrow-band optical source and a focusing lens and the beam splitter lies across the light path from the focusing lens to the detectors. Additionally, a collimating lens may lie between the narrow-band optical source and the gas sample area.

In one particular arrangement, the optical filter and the beam-splitter are combined into a single element; such that <u>either</u> optical radiation whose wavelengths correspond with those absorbed by a sample gas present in the gas sample area, in use, is transmitted and radiation of non-absorbed wavelengths is reflected, <u>or</u> optical radiation whose wavelengths correspond with those absorbed by a sample gas present in the gas sample area, in use, is reflected and radiation of non-absorbed wavelengths is transmitted.

In another particular arrangement, the optical filter is separate from the beam-splitter and arranged such that a first portion of the light beam emergent from the gas sample area is split off and directed to one of the two detectors via the optical filter, and a second portion of the light beam emergent from the gas sample area is split off and directed to the other of the two detectors without passing through any other optical element. The first portion is preferably split off by being reflected by the beam-splitter and the second portion is preferably split off by being transmitted by the beam-splitter.

In yet another embodiment of the "two beam" configuration, the narrow-band optical source is arranged to emit optical radiation towards a focusing or concave mirror which is arranged to direct the reflected optical radiation towards the two detectors, and the gas sample area lies between the source and the mirror.

In one particular arrangement, the two detectors are arranged in the light path of optical radiation reflected from the mirror and are offset from the focal point of such reflected radiation. A single optical filter is included in the light path of one of the two detectors, and no beam-splitter or other optical element is included between the source and the detectors.

In another particular arrangement, a beam-splitter is arranged in the light path of optical radiation reflected from the mirror, and the two detectors are arranged at the respective focal points of the two beam portions of the optical radiation leaving the beam-splitter. A single optical filter is included in the light path from the beam-splitter to one of the two detectors.

In any embodiment or arrangement which includes a beam splitter, the beam-splitter may be arranged to split the incoming beam in the ratio 50:50.

Preferably, in any embodiment or arrangement which includes a single optical filter, the optical filter is arranged, in use, to pass wavelengths corresponding to the absorption spectrum of a target gas under investigation; in this case the said one of the two detectors is a sample detector.

Alternatively, the optical filter is arranged, in use, to block wavelengths corresponding to the absorption spectrum of a target gas under investigation; in this case the said one of the two detectors is a reference detector. Further, in this case, the optical filter may be a dichroic filter, bulk absorption filter, or a gas correlation cell filled with a concentrated sample of the target gas.

According to a second aspect of the present invention, a method of detecting the presence, or measuring the concentration, of a target gas in a gas sample, comprises illuminating the gas sample with radiation from a narrow-band optical source, and passing radiation emergent from the gas sample to a detection arrangement.

In one embodiment of the method according to the second aspect of the present invention, the radiation emergent from the gas sample is passed directly to the detection arrangement without passing through any intervening optical element. The detection arrangement may comprise a single optical detector.

In another embodiment of the method according to the second aspect of the present invention, the radiation emergent from the gas sample is passed to the detection arrangement by way of an intervening optical element. The detection arrangement may comprise two optical detectors. The intervening optical element includes a single optical filter, with or without one or more of a beam-splitter, a focusing lens, a focusing mirror and a collimating lens.

The present invention will now be described in greater detail with reference to the accompanying

diagrammatic drawings which show by way of example only embodiments of the present invention and in which:

Figure 1 is a diagrammatic view of a first embodiment of gas detection system according to the present invention;

Figure 2 is a diagrammatic view of a modification of the gas detection system of the first embodiment;

Figure 3 is a diagrammatic view of a second embodiment of gas detection system according to the present invention;

Figure 4 is a diagrammatic view of a third embodiment of gas detection system according to the present invention;

Figure 5 is a diagrammatic view of a fourth embodiment of gas detection system according to the present invention; and

Figure 6 is a diagrammatic view of a modification of the gas detection system of the fourth embodiment.

Referring to Figure 1, which shows a currently preferred embodiment of the gas detection system of the present invention, a narrow-band, preferably LED, optical source 1 is arranged to emit optical radiation of a limited range of wavelengths inherent in the process by which the source produces its optical emissions, and to direct such optical radiation towards a focusing, i.e. concave, mirror 2. A gas sample to be investigated is, in use, disposed in a gas sampling area 3 where it will be illuminated by

the optical radiation emitted from the narrow-band source 1 as it travels towards the focusing mirror 2. A beam splitter 4 is arranged across the path of optical radiation reflected by the focusing mirror 2 and operates to split the reflected beam into two paths and to direct light along these paths respectively to a first detector 5 and a second detector 6. A single optical filter 7 lies in the path of light from the beam splitter 4 to the second detector 6. The path of light from the beam splitter 4 to the first detector 5 does not include any optical filter.

In operation optical radiation from the narrow-band, LED, light source passes through the gas sample in the gas sample area 3 and is reflected and focused on to the detectors 5, 6 by the focusing mirror 2 and beam splitter 4. The beam split ratio is selected to suit the particular application, but will typically be 50:50. One beam passes directly to the first detector 5, the other beam is split off and passes via the optical filter 7 to the second detector 6. The optical filter 7 may either selectively pass the wavelength corresponding to the absorption spectrum of the target gas, in which case the second detector 6 is the sample detector; or the optical filter 7 may block the wavelengths at which the target gas absorbs, in which case the second detector 6 is the reference detector. In this latter instance, the optical absorption filter 7 could be either a conventional dichroic filter, or bulk absorption filter, or it could be a gas correlation cell filled with a concentrated sample of the target gas.

Signals from the first and second detectors 5, 6 are suitably processed to allow extraction of the

measure of the concentration of target gas present within the gas sample placed within the gas sample area 3.

In a modification of the above-described preferred embodiment of the present invention, and as seen in Figure 2, the beam splitter of Figure 1 is omitted and the first and second detectors 5, 6 are positioned so as to lie off the focal point of the focusing mirror 2.

A second embodiment of the gas detection system of the present invention is shown in Figure 3 in which the optical radiation emitted by the narrow-band, LED, optical source 1 is directed through the gas sample area 3 and straight at the first and second detectors 5, 6 without there being any intervening focusing mirror or other similar optical element.

A third embodiment of the gas detection system of the present invention is shown in Figure 4 and is similar to that of the second embodiment, differing in that the gas sample area 3 between the narrow-band, LED, optical source 1 and detectors 5, 6 is contained within a reflective tube or light concentrator 8.

In all of the foregoing embodiments an optical filter 7 is included in the light path to only one detector, namely, the second detector 6.

A fourth embodiment of the gas detection system of the present invention is shown in Figure 5. A narrow-band, LED, optical source 1 is arranged to emit optical radiation along a path including a collimating lens 9 and a focusing lens 10 and towards a first detector 5 and a second detector 6 respectively

arranged to receive light from the beam splitter 4.

In operation, a gas sample under investigation is disposed in the gas sample area 3 between the collimating and focusing lenses 9, 10 so as to be illuminated by optical radiation emitted by the light source 1. The transmitted optical radiation leaving the focusing lens 10 is split by the beam splitter 4 in a manner similar to that described with reference to the first embodiment. As in the first embodiment, the beam split ratio is selected to suit the particular application, but typically will be 50:50. The optical filter 7, present only in the light path to the second detector 6, may either selectively pass the wavelengths corresponding to the absorption spectrum of the target gas, in which case the second detector 6 is the sample detector; or the optical filter 7 may block wavelengths where the target gas absorbs, in which case the second detector 6 is the reference detector. In this latter configuration, the optical absorption filter 7 could be either a conventional dichroic filter, or bulk absorption filter, or it could be a gas correlation cell filled with a concentrated sample of the target gas.

Signals from the first and second detectors 5, 6 are suitably processed to allow the extraction of the measure of the concentration of the target gas within the gas sample under investigation.

The lens system need not be collimating; instead, a focusing lens could focus the optical radiation from the source 1 directly onto the beam splitter/detector arrangement.

In a modification of the fourth embodiment of gas

detection system, as shown in Figure 6, the separate optical filter 7 is omitted, and in its place is used a combined beam splitter/filter 11 which is used to separate the sample and reference beams. The beam splitter/filter 11 either transmits the optical radiation whose wavelengths correspond with those absorbed by the sample gas, and reflects the non-absorbed wavelengths, or vice versa.

The embodiments described above are all based on the "two beam" or "reference beam" techniques and the use of the narrow-band, LED, optical source saves on the need to use two optical filters, one in each detector channel.

The gas detection system of the present invention may, however, be based on the "single beam" technique, in which case a narrow-band, LED, optical source (not shown) is arranged to emit optical radiation towards a single detector (also not shown) and along a light path including a gas sample area lying between the source and detector, no other optical element such as an optical filter or beam splitter being included in this instance. Thus, in the "single beam" configuration, the present invention dispenses with the need for any filter at all.

Whilst the use of an LED light source is currently preferred in execution of the concept of the present invention, it is envisaged that other suitable narrow-band light sources, for example, laser sources, may be used instead. In order to qualify as "suitable" in the context of the present invention, a narrow-band light source is required to emit optical radiation over such a narrow range of wavelengths relative to the normal optical spectrum such that in

arranged to receive light from the beam splitter 4.

In operation, a gas sample under investigation is disposed in the gas sample area 3 between the collimating and focusing lenses 9, 10 so as to be illuminated by optical radiation emitted by the light source 1. The transmitted optical radiation leaving the focusing lens 10 is split by the beam splitter 4 in a manner similar to that described with reference to the first embodiment. As in the first embodiment, the beam split ratio is selected to suit the particular application, but typically will be 50:50. The optical filter 7, present only in the light path to the second detector 6, may either selectively pass the wavelengths corresponding to the absorption spectrum of the target gas, in which case the second detector 6 is the sample detector; or the optical filter 7 may block wavelengths where the target gas absorbs, in which case the second detector 6 is the reference detector. In this latter configuration, the optical absorption filter 7 could be either a conventional dichroic filter, or bulk absorptio filter, or it could be a gas correlation cell fille with a concentrated sample of the target gas.

Signals from the first and second detectors 5, are suitably processed to allow the extraction of th measure of the concentration of the target gas with the gas sample under investigation.

The lens system need not be collimating; instea a focusing lens could focus the optical radiation fr the source 1 directly onto the beam splitter/detec arrangement.

In a modification of the fourth embodiment of

CLAIMS

1. A gas detection system comprising a narrow-band optical source arranged to illuminate a gas sample area, and a detection arrangement downstream of the gas sample area.

2. A gas detection system according to claim 1, wherein the optical source comprises a light emitting diode.

3. A gas detection system according to claim 1, wherein the optical source comprises a laser.

4. A gas detection system according to any preceding claim, wherein the detection arrangement comprises a single optical detector.

5. A gas detection system according to claim 4, wherein the narrow-band optical source is arranged to emit optical radiation towards the single detector and along a light path including the gas sample area lying between the source and detector, and wherein no optical filter, beam splitter, or other optical element is included between the source and detector.

6. A gas detection system according to any of claims 1 to 3, wherein the detection arrangement comprises two optical detectors.

7. A gas detection system according to claim 6, wherein the detection arrangement includes only one optical filter.

8. A gas detection system according to claim 7, wherein the optical filter is included in the light

path to only one of the two detectors.

9. A gas detection system according to claim 8, wherein the narrow-band optical source is arranged to emit optical radiation towards the two detectors and along light paths including the gas sample area lying between the source and detectors, wherein the optical filter lies between the gas sample area and said one of the two detectors, and wherein no beam splitter or other optical element is included between the source and detectors.

10. A gas detection system according to any of claims 6 to 9, wherein the gas sample area is contained within a reflective tube or light concentrator which extends at least partially between the optical source and the detectors.

11. A gas detection system according to claim 8, wherein the narrow-band optical source is arranged to emit optical radiation towards the two detectors and along light paths including the gas sample area lying between the source and detectors, wherein the optical filter lies between the gas sample area and said one of the two detectors, and wherein an optical beam-splitter lies between the gas sample area and the two detectors.

12. A gas detection system according to claim 11, wherein the gas sample area lies between the narrow-band optical source and a focusing lens and wherein the beam splitter lies across the light path from the focusing lens to the detectors.

13. A gas detection system according to claim 12, wherein a collimating lens lies between the narrow-

band optical source and the gas sample area.

14. A gas detection system according to any of claims 11 to 13, wherein the optical filter and the beam-splitter are combined into a single element, whereby optical radiation whose wavelengths correspond with those absorbed by a sample gas present in the gas sample area, in use, is transmitted and radiation of non-absorbed wavelengths is reflected.

15. A gas detection system according to any of claims 11 to 13, wherein the optical filter and the beam-splitter are combined into a single element, whereby optical radiation whose wavelengths correspond with those absorbed by a sample gas present in the gas sample area, in use, is reflected and radiation of non-absorbed wavelengths is transmitted.

16. A gas detection system according to any of claims 11 to 13, wherein the optical filter is separate from the beam-splitter, whereby a first portion of the light beam emergent from the gas sample area is split off and directed to said one of the two detectors via the optical filter, and a second portion of the light beam emergent from the gas sample area is split off and directed to the other of the two detectors without passing through any other optical element.

17. A gas detection system according to claim 16, wherein the first portion is split off by being reflected by the beam-splitter and the second portion is split off by being transmitted by the beam-splitter.

18. A gas detection system according to any of claims 6 to 8, wherein the narrow-band optical source is

arranged to emit optical radiation towards a focusing or concave mirror which is arranged to direct the reflected optical radiation towards the two detectors, the gas sample area lying between the source and the mirror.

19. A gas detection system according to claim 18, wherein the two detectors are arranged in the light path of optical radiation reflected from the mirror and offset from the focal point of such reflected radiation.

20. A gas detection system according to claim 19 when dependent on claim 7 or 8, wherein said one optical filter is included in the light path of one of the two detectors, and wherein no beam-splitter or other optical element is included between the source and the detectors.

21. A gas detection system according to claim 18, wherein a beam-splitter is arranged in the light path of optical radiation reflected from the mirror, and the two detectors are arranged at the respective focal points of the two beam portions of the optical radiation leaving the beam-splitter.

22. A gas detection system according to claim 21 when dependent on claim 7 or 8, wherein said one optical filter is included in the light path from the beam-splitter to one of the two detectors.

23. A gas detection system according to any of claims 11 to 17, 21 and 22, wherein the beam-splitter is arranged to split the incoming beam in the ratio 50:50.

24. A gas detection system according to any of claims 7 to 23, wherein the optical filter is arranged, in use, to pass wavelengths corresponding to the absorption spectrum of a target gas under investigation, and wherein one or said one of the two detectors is a sample detector.

25. A gas detection system according to any of claims 7 to 23, wherein the optical filter is arranged, in use, to block wavelengths corresponding to the absorption spectrum of a target gas under investigation, and wherein one or said one of the two detectors is a reference detector.

26. A gas detection system according to claim 25, wherein the optical filter is a dichroic filter, bulk absorption filter, or a gas correlation cell filled with a concentrated sample of the target gas.

27. A gas detection system according to claim 6, or any of claims 7 to 26 when dependent upon claim 6, wherein signals from the two detectors are processed to enable extraction of the concentration of a target gas within the gas sample under investigation, in use.

28. A method of detecting the presence, or measuring the concentration, of a target gas in a gas sample, comprising illuminating the gas sample with radiation from a narrow-band optical source, and passing radiation emergent from the gas sample to a detection arrangement.

29. A method according to claim 28, wherein the optical source comprises light emitting diode.

30. A method according to claim 28, wherein the

optical source comprises a laser.

31. A method according to any of claims 28 to 30, wherein the radiation emergent from the gas sample is passed directly to the detection arrangement without passing through any intervening optical element.

32. A method according to claim 31, wherein the detection arrangement comprises a single optical detector.

33. A method according to any one of claims 28 to 30, wherein the radiation emergent from the gas sample is passed to the detection arrangement by way of an intervening optical element.

34. A method according to claim 33, wherein the detection arrangement comprises two optical detectors.

35. A method according to claim 33 or claim 34, wherein the intervening optical element includes one optical filter, with or without one or more of a beam-splitter, a focusing lens, a focusing mirror and a collimating lens.

36. A gas detection system substantially as herein described with reference to Figure 1, or Figure 2, or Figure 3, or Figure 4, or Figure 5, or Figure 6 of the accompanying drawings.

37. A method of detecting the presence, or measuring the concentration, of a target gas in a gas sample, substantially as herein described with reference to Figure 1, or Figure 2, or Figure 3, or Figure 4, or Figure 5, or Figure 6 of the accompanying drawings.

The Patent Office

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Application No: GB 9614040.5
Claims searched: 1-37

Examiner: M. G. Clarke
Date of search: 14 November 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1A ACDD, ACDG

Int Cl (Ed.6): G01N 21/31, 21/33, 21/35, 21/39

Other: -----------

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2264170A	Isis Innovation Ltd. - whole document	1,2,4,5 at least
X	EP0462755A1	Laser Monitoring Systems Ltd. - see especially Fig. 1	1,2,6,7, 27-29, 33-35 at least
X	WO94/17389A1	Telaire Systems Inc. - see esp. Figs. 3,4	1, 3-5, 28,30-32 at least
X	US4526034	assigned to Campbell Scientific Inc. - see especially Figs. 3-5 and columns 4,5	1,4,5,28, 31,32 at least
X	Measurement Science and Technology 3 1992 (UK), Sean F.Johnston, "Gas monitors employing infrared LEDs", pages 191-195, especially Figs. 2 and 4		1, 2, 4-7, 10,14,18, 19, 21, 27-29, 31-35 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
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